#16 Appeal Brief 8/12/03 ARJ

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IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF	:
Youichi ISHIMURA, et al.	: EXAMINER: TRAN, T.
SERIAL NO: 09/881,675	:
FILED: JUNE 18, 2001	: GROUP ART UNIT: 2811
FOR: FIELD-EFFECT SEMICONDUCTOR DEVICE	:

APPEAL BRIEF UNDER 37 C.F.R. § 1.192

COMMISSIONER FOR PATENTS
ALEXANDRIA, VIRGINIA 22313

SIR:

This is an appeal from a Final Office Action mailed January 3, 2003. A Notice of Appeal was timely filed on May 2, 2003.

I. REAL PARTY IN INTEREST

The real party in interest in this appeal is Mitsubishi Denki Kabushiki Kaisha, having an address at 2-3, Marunouchi 2-chome, Chiyoda-ku, TOKYO 100-8310 JAPAN.

II. RELATED APPEALS AND INTERFERENCES

Appellants, Appellants' legal representatives, and the assignees are aware of no appeals or interferences which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

III. STATUS OF THE CLAIMS

Claims 1-10, all the claims in the application, stand finally rejected and are herein appealed.

IV. STATUS OF THE AMENDMENTS

An amendment after final was timely filed March 31, 2003. In an Advisory Action mailed April 8, 2003, the Examiner maintained the Final rejection of Claims 1-10. A Notice of Appeal was timely filed on May 2, 2003. Although it was not formally stated in the Advisory Action whether or not the Amendment filed April 3, 2003 would be entered for purposes of appeal, Appellants assume that the Amendment is entered to correct a typographical error in the Specification and Claim 5. The attached Appendix I reflects Claims 1-10 as presently pending on appeal.

V. SUMMARY OF THE INVENTION

The claimed invention relates to a field-effect semiconductor device having a MOS gate. One object of the claimed invention is to provide an insulated gate bipolar transistor that is capable of achieving a greater amount of breakdown withstanding without any additional complex production processes.[1] Further, as described in the specification at pages 9 and 10, for example, the Applicants discovered that including nitrogen in a barrier metal layer greatly improves threshold voltage characteristics after annealing processing.[2] Based on the Applicants' discoveries, Applicants determined that p-based density may be raised to obtain the same threshold voltage by forming a barrier metal layer containing nitrogen. As a result, the pinch resistance of the p-based region immediately beneath the n^+-emitter regions

[1] Specification, page 4, lines 6-9.
[2] Specification, page 10, lines 1-4.

may be lowered, so that an IGBT having a greater amount of breakdown withstanding may be provided.[3]

With reference to Figure 1 as a non-limiting example, Claim 1 recites a field-effect semiconductor device having a semiconductor layer of a first conductivity type (2 and 3), a collector region (4) of a second conductivity type that is formed beneath said semiconductor layer and equipped with a collector electrode (5) on its lower surface (4a), a base region (6) of the second conductivity type that is formed as part of the upper surface of said semiconductor layer, at least one pair of emitter regions (7) of the first conductivity type that are formed as part of the upper surface of said base region (6), an insulating layer (8) that is formed to contact said base region (6) that is located between said emitter regions (7) and said semiconductor layer (2 and 3), a gate electrode (9) that is placed on the upper surface of said insulating layer (8), an interlayer insulating film (11) that is formed to cover said gate electrode (9), a barrier metal layer (12) that is formed to continuously contact said interlayer insulating film (11), base region (6), and emitter regions (7), and an emitter electrode (13) that is formed on the upper surface of said barrier metal layer (12), characterized in that said barrier metal layer (12) that is formed between said emitter electrode (13) and said interlayer insulating film (11) comprises a layer containing nitrogen.

Similarly, with reference to Figure 1 as the non-limiting example, Claim 6 recites a field-effect semiconductor device having a semiconductor layer of a first conductivity type (2 and 3), wherein said semiconductor layer comprises a buffer layer (3) of a first doping concentration and a second layer (2) of a second doping concentration, wherein said first doping concentration is higher than said second doping concentration; a collector region (4) of a second conductivity type formed beneath said semiconductor layer and equipped with a collector electrode (5) on its lower surface (4a); a base region (6) of the second conductivity

[3] Specification, page 10, lines 12-18.

type formed as part of the upper surface of said semiconductor layer (2 and 3); at least one pair of emitter regions (7) of the first conductivity type formed as part of the upper surface of said base region (6); an insulating layer (8) formed to contact said base region (6), located between said emitter regions (7) and said semiconductor layer (2 and 3); a gate electrode (9) placed on the upper surface of said insulating layer (8); an interlayer insulating film (11) formed to cover said gate electrode (9); a barrier metal layer (12) formed to continuously contact said interlayer insulating film (11), said base region (6), and said emitter regions (7); and an emitter electrode (13) formed on the upper surface of said barrier metal layer (12), wherein said barrier metal layer (12) formed between said emitter electrode (13) and said interlayer insulating film (11) comprises a layer containing nitrogen.

VI. ISSUES

The first issue for review is whether one or more of Claims 1-3 and 5 are unpatentable over Sakurai et al. (U.S. Pat. No. 5,962,877, hereafter Sakurai), in view of Sakurai et al. (JP 411284176 A, hereafter JP '176) and Okamoto et al. (U.S. Pat. No. 4,903,117, hereafter Okamoto) under 35 U.S.C. § 103(a). The second issue for review is whether Claim 4 is unpatentable over Sakurai in view of JP '176 and Okamoto and further in view of Kim et al. (U.S. Pat. No. 6,229,166, hereafter Kim) under 35 U.S.C. § 103(a). The third issue for review is whether one or more of Claims 6-8 and 10 are patentable over Figure 6 of the present application in view of JP '176 and Okamoto under 35 U.S.C. § 103(a). The fourth issue for review is whether Claim 9 is patentable over Figure 6 in view of JP '176 and Okamoto and further in view of Kim under 35 U.S.C. § 103(a).

VII. GROUPING OF THE CLAIMS

For the first issue, Claims 1-3 and 5 stand together. For the second issue, Claim 4 stands alone. For the third issue, Claims 6-8 and 10 stand together. For the fourth issue, Claim 9 stands alone.

VIII. ARGUMENT

A. The First Issue, Claims 1-3 and 5.

The Final Office Action explicitly rejects Claims 1-3 and 5 as unpatentable over Sakurai in view of JP '176 and Okamoto. Independent Claim 1 recites that a barrier metal layer is formed between the emitter electrode and the interlayer insulating film and includes a layer containing nitrogen.

At the outset, in order to establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations.[4] Additionally, "[t]he teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant's disclosure."[5] Appellants submit that at a minimum, the first two requirements have not been satisfied in this case.

[4] See, MPEP § 2143.
[5] *In re Vaeck*, 947 F. 2d 488, 20 U.S. P.Q. 2d 1438 (Fed. Cir. 1991).

1. There is no motivation to combine the teachings of Sakurai, JP '176, and Okamoto.

The Office Action states at page 3, lines 11-17:

> It would have been obvious to a person having ordinary skill in the art at the time the invention was made to modify the structure of Sakurai et al. (US reference) by forming the emitter electrode 12 of aluminum and providing a barium metal layer having a thickness of more than 60 nm as taught by the Sakurai Japanese reference so that the emitter electrode of aluminum provides relatively low resistivity and low cost, and the barrier metal layer continuously contacts said insulating film, base region, and emitter regions to eliminate silicon residue and prevent aluminum diffusion into the silicon substrate.

Additionally, the Office Action asserts at page 3, line 18, through page 4, line 1:

> Molybdenum silicide and titanium nitride are barrier materials known in the art and routinely used to form barrier metal layer (sic) in semiconductor device as shown for example by Okamoto et al. ... to prevent spiking in the junction between the emitter electrode and the silicon substrate, to obtain low resistance ohmic contact and to serve as an excellent diffusion barrier between aluminum and silicon.

However, Appellants respectfully submit that there is simply no motivation to make the applied combination.

First, Sakurai relates to an inverter apparatus having an improved switching element. As admitted in the Final Office Action, at page 3, Sakurai does not disclose or suggest a barrier metal layer formed to continuously contact the interlayer insulating film, as recited in the pending claims. Moreover, Sakurai does not disclose or suggest that the barrier metal layer may include nitrogen. In fact, there is no teaching or suggestion anywhere in Sakurai that including nitrogen will provide any benefits, such as improving voltage characteristics. Additionally, Sakurai does not disclose or suggest that an emitter might be formed of aluminum.

JP '176 provides *pure* aluminum at an emitter electrode while a barrier layer is provided between the emitter electrode and a MOS gate. JP '176 indicates that a barrier layer

is useful for an emitter composed of *pure* aluminum. As the barrier metal layer of JP '176 is specifically noted for its use with pure aluminum in the structure of JP '176, it is respectfully submitted that one of ordinary skill in the art would not have been motivated to combine the non-aluminum structure of Sakurai with the barrier metal layer of the differing structure of JP '176.

Okamoto relates to insulating films that have contact holes selectively formed within the films. The film configuration of Okamoto is described as able to prevent the precipitation of silicon into the contact hole.[6] However, Okamoto does not disclose or suggest that the withstanding voltage may be improved in an IGBT, as discovered by the Applicants.

Okamoto merely suggests that titanium nitrine and tantalum nitride may be useful to avoid alloy spike phenomena in the junction between the barrier layer and the silicon substrate.[7] Okamoto certainly does not suggest that a barrier layer containing nitrogen would be beneficial in a structure having an aluminum emitter. Specifically, Okamoto does not disclose or suggest the use of any type of emitter, regardless of the emitter composition. In fact, although the second metal layer 6 of Okamoto is described as containing aluminum, Okamoto only describes that boron is prevented from diffusing and silicon is prevented from precipitating.[8]

Thus, the Final Office Action must be relying on knowledge generally available to one of ordinary skill in the art as providing the motivation to combine the reference teachings. However, the level of skill in the art cannot be relied upon to provide the suggestion to combine references.[9]

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[6] Okamoto, Abstract.
[7] Okamoto, col. 3, lines 7-12.
[8] Okamoto, col. 3, lines 17-23.
[9] *Al-Site Corp. v. VSI Int'l Inc.*, 174 F.3d 1308, 50 U.S.P.Q. 2d 1161 (Fed. Cir. 1999).

2. There Is No Reasonable Expectation of Success in Combining the Cited References.

It is also evident that there is no reasonable expectation of success when combining Sakurai, JP '176, and Okamoto. First, as noted above, the structures described in Sakurai, JP '176, and Okamoto are very distinct.

As noted above, Sakurai does not disclose or suggest a barrier metal layer formed to continuously contact the interlayer insulating film. Moreover, Sakurai does not disclose or suggest that the barrier metal layer may include nitrogen. Finally, Sakurai does not disclose or suggest that an emitter may be formed of aluminum.

Combining the structure of JP '176, which describes pure aluminum at an emitter electrode while a barrier layer is provided between the emitter electrode and a MOS gate, with the non-aluminum structure of Sakurai is simply not supported by the teachings of either reference. Specifically, JP '176 indicates that a barrier layer is useful for an emitter composed of pure aluminum. As Sakurai does not disclose or suggest that an emitter is formed of aluminum, that there is certainly no disclosure or suggestion that the barrier metal layer of JP '176 would be useful in a non-aluminum configuration such as that of Sakurai.

Additionally, as noted above, Okamoto does not disclose or suggest that a barrier layer containing nitrogen would be beneficial in a structure having an aluminum emitter. In fact, Okamoto does not disclose or suggest the use of any type of emitter, let alone a specific emitter composition. Therefore, the combination of Okamoto with JP '176 and Sakurai certainly does not find any support within any of these three references.

Absent the Appellants' written description in the specification, it is difficult to imagine how these very distinct structures could be combined to achieve the Appellants' invention. Therefore, it is respectfully submitted that one of ordinary skill in the art would not apply the teachings of JP '176 and Okamoto to the teachings of Sakurai, because there

was no expectation of successfully achieving a IGBT having a greater amount of breakdown withstanding.

B. The Second Issue, Claim 4.

Claim 4 was rejected as unpatentable over Sakurai in view of JP '176 and Okamoto as applied to Claims 1-3 and 5, and further in view of Kim. Claim 4 depends from Claim 1.

As noted above, there must be some suggestion or motivation, either in the references themselves or the knowledge generally available to one of ordinary skill in the art to modify the reference or to combine reference teachings. Additionally, there must be a reasonable expectation of success in the combination of the references. It is respectfully submitted that neither of these criteria are satisfied in this case.

1. There Is No Motivation or Suggestion in Any of Sakurai, JP '176, Okamoto, or Kim to Support the Applied Combination.

As noted above, there is no motivation in the teachings of any of Sakurai, JP '176, or Okamoto to support the applied combination. Appellants respectfully submit that Kim fails to remedy the deficiencies of the teachings of Sakurai, JP '176, and Okamoto.

Kim relates to a ferroelectric random access memory device and fabrication method. Kim describes providing an upper and lower seed layer that is crystallized prior to the ferroelectric layer during thermal treatment.[10] However, Kim does not disclose or suggest the use of any type of emitter and certainly fails to disclose or suggest that an emitter may be formed of aluminum. Kim further does not disclose or suggest the use of any type of barrier layer. In light of these deficiencies, there is clearly a lack of motivation in Kim to support the combination with the barrier layer of JP '176 and the emitter of Sakurai..

[10] Kim, Abstract.

Consequently, as it is evident that the structures described in Sakurai, JP '176, Okamoto, and Kim are quite distinct from each other, and there is no suggestion or motivation to modify the references that may be found within the teachings of these references, it is respectfully submitted that the Final Office Action has failed to carry its burden with regard to the first element of a *prima facie* case of obviousness.

2. There Is No Reasonable Expectation of Success Within the Teachings of Any of Sakurai, JP '176, Okamoto, or Kim to Support the Applied Combination.

As noted above, there is no expectation of success for the combination of the references may be found in any of Sakurai, JP '176, or Okamoto. Specifically, none of these three references discloses or suggests that including nitrogen in a barrier metal layer would greatly improve threshold voltage characteristics after annealing processing. Additionally, as noted above, there is no disclosure or suggestion within any of Sakurai, JP '176, or Okamoto that p-based density may be raised to obtain the same threshold voltage by forming a barrier metal layer containing nitrogen, which lowers the pinch resistance of the p-based region immediately beneath the n^+-emitter region, so that an IGBT having a greater amount of breakdown withstanding may be provided.

It is respectfully submitted there is no expectancy of Kim that these characteristics could be achieved. As Kim fails to disclose or suggest the use of any type of emitter, or the use of any type of barrier layer, it is respectfully submitted that there is certainly no suggestion that providing a barrier metal layer containing nitrogen with an emitter would improve the characteristics of an IGBT.

C. The Third Issue, Claims 6-8 and 10.

The Final Office Action explicitly rejects Claims 6-8 and 10 as unpatentable over Figure 6 in view of JP '176 and Okamoto. Independent Claim 6, from which Claims 7, 8, and 10 depend recites that a barrier metal layer is formed between the emitter electrode and the interlayer insulating film and includes a layer containing nitrogen.

Initially, it is noted that in order to provide a *prima facie* case of obviousness, the Final Office Action must have some suggestion or motivation, either in the references themselves, or in the knowledge generally available to one of ordinary skill in the art to modify the reference or to combine the reference teachings. The teaching or suggestion to make the claim combination and reasonable expectation of success must both be found in the prior art, not in Applicants' disclosure.[11] The Final Office Action relies upon the description of Figure 6 found in the Background of the Invention section of the Applicants' disclosure to make the final rejection of Claims 6-8 and 10.

As earlier noted, there is no support in the teachings of either JP '176 or Okamoto to support the combination of these references. It is respectfully submitted that the description of Figure 6 fails to remedy the deficiencies above-noted with respect to JP '176 and Okamoto.

Specifically, it is only in light of the Appellants' written description in the present specification that the proposed combination may be derived. For example, it is only in light of the Appellants' description in the Background of the Invention section at pages 1-3 that the deficiencies of the prior art are realized. It is this description of the Appellants' inventive efforts that forms the basis for the outstanding final rejection of Claims 6-8 and 10. Consequently, as the Appellants' own written description is providing the motivation to combine the cited references and because the teaching or suggestion to make the claimed

[11] MPEP § 2143.

combination and the reasonable expectation of success must both be found in the prior art, not in the Applicants' disclosure, as set forth in MPEP § 2143, it is respectfully submitted the combination of Figure 6, JP '176, and Okamoto is improper.

D. The Fourth Issue, Claim 9.

Claim 9 stands finally rejected over Figure 6 in view of JP '176, Okamoto, and further in view of Kim.

As noted above, there is no support in the teachings of JP '176, Okamoto, or Kim to provide a motivation or reasonable expectation of success based upon the applied combination. It is respectfully submitted that Figure 6 does not remedy the defects of the combination of JP '176, Okamoto, and Kim.

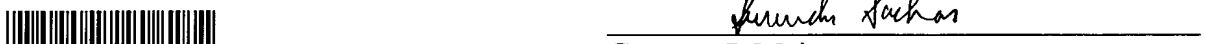
As noted above, it is only in light of the Appellants' description in the Background of the Invention section at pages 1-3 of the specification, for example, that the present invention becomes obvious. Therefore, because it is improper for a rejection to rely upon the Applicants' own inventive efforts and disclosure for a rejection, it is respectfully submitted that the Patent Office has not carried forth its burden with regard to the rejection of Claim 9.

IX. CONCLUSION

Appellants submit that the references neither disclose nor suggest the semiconductor device of Claims 1-10. Accordingly, it is respectfully requested that all rejections still pending in the Final Office Action be REVERSED.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, P.C.



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APPENDIX I

1. A field-effect semiconductor device having a semiconductor layer of a first conductivity type, a collector region of a second conductivity type that is formed beneath said semiconductor layer and equipped with a collector electrode on its lower surface, a base region of the second conductivity type that is formed as part of the upper surface of said semiconductor layer, at least one pair of emitter regions of the first conductivity type that are formed as part of the upper surface of said base region, an insulating layer that is formed to contact said base region that is located between said emitter regions and said semiconductor layer, a gate electrode that is placed on the upper surface of said insulating layer, an interlayer insulating film that is formed to cover said gate electrode, a barrier metal layer that is formed to continuously contact said interlayer insulating film, base region, and emitter regions, and an emitter electrode that is formed on the upper surface of said barrier metal layer, characterized in that said barrier metal layer that is formed between said emitter electrode and said interlayer insulating film comprises a layer containing nitrogen.

2. The field-effect semiconductor device according to claim 1, wherein said barrier metal layer that is formed between said emitter electrode and said interlayer insulating film comprises titanium nitride.

3. The field-effect semiconductor device according to claim 1, wherein the thickness of said barrier metal layer is more than 40 nm.

4. The field effect semiconductor device according to claim 1, wherein the impurity density of said interlayer insulating film is less than 5 mol %.

5. The field-effect semiconductor device according to claim 1, wherein said emitter electrode comprises aluminum.

6. A field-effect semiconductor device comprising:

a semiconductor layer of a first conductivity type, wherein said semiconductor layer comprises a buffer layer of a first doping concentration and a second layer of a second doping concentration, wherein said first doping concentration is higher than said second doping concentration;

a collector region of a second conductivity type formed beneath said semiconductor layer and equipped with a collector electrode on its lower surface;

a base region of the second conductivity type formed as part of the upper surface of said semiconductor layer;

at least one pair of emitter regions of the first conductivity type formed as part of the upper surface of said base region;

an insulating layer formed to contact said base region, located between said emitter regions and said semiconductor layer;

a gate electrode placed on the upper surface of said insulating layer;

an interlayer insulating film formed to cover said gate electrode;

a barrier metal layer formed to continuously contact said interlayer insulating film, said base region, and said emitter regions; and

an emitter electrode formed on the upper surface of said barrier metal layer,

wherein said barrier metal layer formed between said emitter electrode and said interlayer insulating film comprises a layer containing nitrogen.

7. The field-effect semiconductor device according to claim 6, wherein said barrier metal formed between said emitter electrode and said interlayer insulating film comprises titanium nitride.

8. The field-effect semiconductor device according to claim 6, wherein the thickness of said barrier metal layer is more than 40 nm.

9. The field-effect semiconductor device according to claim 6, wherein the impurity density of said interlayer insulating film is less than 5 mol %.

10. The field-effect semiconductor device according to claim 6, wherein said emitter electrode comprises aluminum.